U. S. DEPARTMENT OF COMMERCE

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

NATIONAL OCEAN SERVICE

National Geodetic Survey
Charles W. Challstrom, Acting Director

Project Report

for

Survey Section B

Texas FBN, 1998

GPS-1267

Task Numbers:
8K6D2000(FBN)
8K6D5000(HGCSD)

Clifton S. Middleton
Project Director, Section B

CONTENTS

I. INTRODUCTION

A. Authority

Project GPS-1267 was conducted complying to project instructions titled "Texas FBN, 1998" dated April 1, 1998 signed by Charles W. Challstrom, NOAA, Acting Director, National Geodetic Survey.

B. Purpose

The survey project supports the National Geodetic Survey (NGS) Strategic Plan by observing stations of the Federal Base Network (FBN) to complete the ellipsoidal and orthometric height components of the FBN. The project is to also support software tests that will determine if FBN surveys can be computed along with standard CORS processing. Seven tide sites along the Gulf of Mexico, six stations in the Harris-Galveston Coastal Subsidence District (HGCSD), and four other HGCSD stations from a previous project were included in the project.

To meet America's accelerating positioning and navigation needs by enhancing the existing coordinate reference system to provide the accessibility and high accuracy required for use by GPS. The digital revolution in mapping, charting, and surveying requires a National Spatial Reference System (NSRS) consisting of, among other components, a network of monumented points having four-dimensional positions. The FBN fulfills the requirements for this component and NGS is charged with the Federal responsibility for establishment, observation, monitoring, and maintenance of the FBN.

The NSRS provides the common geographic framework for America's spatial data infrastructure. In this capacity, the NSRS serves as the basis for mapping, charting, navigation, boundary determination, property delineation, infrastructure development, resource evaluation surveys, and scientific applications, including crustal motion monitoring, modeling of flooding, storm surge, pollution trajectories, and agricultural runoff. A modernized, accurate, consistent, and reliable NSRS is of enormous benefit to state, county, tribal, local, and federal authorities, as well as the private sector.

The survey ties to the seven tide sites is to provide GPS-derived ellipsoid heights, accurate to 3 CM, on tide site water-level marks along the coast.

The survey ties to the six additional and the four re-observed HGCSD stations is to provide GPS-derived ellipsoid heights, accurate to 3 cm, and a tie between the local network and the national FBN network. It will also provide a check to determine if the ellipsoid heights can be repeated to within 3 cm in the HGCSD area.

C. Time Period

Reconnaissance of the part of the Federal Base Network, the Harris-Galveston Coastal Subsidence District, and the tide sites was performed by Bill Waikman from December 18, 1997 to March 6, 1998. The reconnaissance for the remainder of the Federal Base Network was performed by Bob Hayes from January 21, 1998 to March 6, 1998.

The observation of the FBN network commenced on March 13, 1998 (Julian day 076) and concluded on June 3, 1998 (Julian day 154). Data processing,

bluebooking and adjustment were completed on March 5, 1999.

II. **LOCATION**

A. **Locality**

The project consisted of one hundred and eleven stations located in 5 states. A list of stations in a particular state follows:

Texas FBN Stations

27 WWF USGS 1951
A 1236
A 1461
A 256
ACALA
AIKEN
ALEDO 3
ALLAMORE
ALLISON **)**
ARONICA AZ MK 2
AUSTIN
B 703
C 1304
CHERRY
D 1490
DERBY
DRYDEN WEST BASE
ELM
ELMENDORF SE BASE AZ MK
EL PASO
F 1436
FROST
G 1432
G 1457
GIBBONS 2
GIBSON RESET
H 1481
H 506
J 1174
J 1487
KERR
KINGSTONE RESET
L 1114
L 550 RESET
LAMPASAS CBL 0
LINN
LOLITA
LOS OLMOS 2
LOULA
M 1396
M 1497
MCGILL
N 1414
N 234
NEWCASTLE
NINE 2
P 1391
PALPORT
PARILEY 2
POST
PRESIDIO S BASE
QUEBEC RESET
R 1446
REALITOS NORTH BASE RM 2
REDFIELD 2
S 1443
SMETANA
T 747
TT37BR
U 142
WAELDER RM 2
WILKINS W BASE RESET
X 1406 (is also at a tidal site)
X 1428
Y 1482
Z 1063
ZAPATA RESET

Texas HGCSD Stations

HGCSD 15
HGCSD 26
HGCSD 51
HGCSD 68
HGCSD 73

Texas HGCSD Re-observed Stations

74+09.45
75+28
877 1510 TIDAL 46
NASS RM 1

HGCSD 78
HGCSD 80

TXDOT CORS Stations
AMARILLO RRP CORS ARP
SAN ANTONIO RRP CORS ARP
ARLINGTON RRP CORS ARP
AUSTIN RRP CORS ARP
BEAUMONT RRP CORS ARP
CORPUS CHRISTI RRP CORS ARP *****
HOUSTON RRP CORS ARP
LUBBOCK RRP CORS ARP
ODESSA RRP CORS ARP
EL PASO RRP CORS ARP

Arkansas CORS Station
DEQUEEN 1 CORS ARP

New Mexico CORS Stations
TUCUMCARI CORS ARP
WHITE SANDS CORS ARP

Oklahoma CORS Stations
PURCELL CORS ARP
VICI CORS ARP

Texas Tidal Site Stations
0570 A
2440 A
877 1450 TIDAL 40 RESET
877 4770 TIDAL 4
877 5870 H TIDAL
90025 C
E 168

Texas CORS Stations
ARANSAS PASS 3 CORS ARP
GALVESTON 1 CORS ARP
JAYTON CORS ARP
MCDONALD CORS MONUMENT
PALESTINE CORS ARP

Louisiana CORS Stations
WINNFIELD CORS ARP

Louisiana Ties Stations
7 V 1
FAA LA24 A
MOSS
PATSY AZ MK
VINTON

) The surface mark at **ALLISON RESET** has been destroyed. The original sub-surface mark is what is being used. The station name has been changed back to **ALLISON**.

*** CORPUS CHRISTI RRP CORS ARP** was changed to **CORPUS CHRISTI CORS ARP** sometime during the project. This change was not found until all the data had been processed. The name was not changed in any of the files, processing, or report within this project.

B. **Limits**

Survey operations were roughly within the boundaries of:

North	36 deg 27 min	North Latitude
South	26 deg 03 min	North Latitude
East	092 deg 46 min	West Longitude
West	106 deg 36 min	West Longitude

III. CONDITIONS AFFECTING PROGRESS

Eric Black locked the key to the rental vehicle in the vehicle as he was starting the equipment set-up at station M 1497 for the session on Julian day 078. By the time a spare key was obtained, the session was mostly over. The occupation was made up on Julian day 107.

Eric Black did not pay attention to details and collected only 5 1/2 hours of data on a required 7 hour session at 877 1510 TIDAL 46 on Julian day 087.

This was a Saturday for which the operators were receiving overtime. The session was re-observed on Julian day 111.

Eric Black set-up on the station mark which was under trees instead of WAELDER RM 2 as per the description on Julian day 091. The station was re-observed on Julian day 113.

On Julian day 092, Eric Keresty had a mechanical failure on the government truck and had to have it towed to a service station for repairs. This resulted in a missed occupation of station LOLITA. The station was re-observed on Julian day 113.

IV. ORGANIZATION OF PARTY

A. Personnel

The following personnel from NGS were involved in the project's operations:

Clifton Middleton	Project Director
Gary Means	Computer (Field & Office)
Daniel Callahan	Computer (Office)
Ronald Bailey	Observer
Eric Black	Observer
Justin Dahlberg	Observer
Joseph Di Mare	Observer
Eric Keresty	Observer
David Nock	Observer
Vincent Piczak	Observer
Timothy Wilkins	Observer
Bill Waikman	Reconnaissance
Robert Hayes	Reconnaissance

B. Liaison

Communications were maintained with William McLemore and Nancy McCary of the Field Operations Branch.

Communications were maintained with Dennis Hoar, Juliana Blackwell, and Maralyn Vorhauer of the Observation and Analysis Division.

Communications were maintained with Douglas Hendrickson and Stephen Frakes of the Project Development Branch.

Communications were maintained with Stephen Hilla of the Systems Development Division.

Communications were maintained with receiver operators and other individuals associated with the project.

Communications were maintained with property owners and various government agencies at station sites.

V. FIELD WORK

A. Chronology

See Attachment D, Observation Schedules, for a summary of daily events and see Office Processing for a summary of conditions affecting data collection or quality.

B. **Instrumentation**

A total of twenty-nine GPS receivers were used to complete the Texas area survey: twenty-one Trimble 4000SSE receivers, five Trimble 4000SSI receivers, two Ashtech Z-XII3 receivers and one Allen Osborne Assc. Rogue SNR 8000 receiver. A list of the receivers, as well as a list of the agencies that owned and operated them follows:

Type	ID	Serial Number	Owner	Operator	
Trimble 4000SSE	286	3432A07286	NGS	NGS	(1)
	526	3534A11526	NGS	NGS	
	869	3402A04869	NGS	NGS	
	871	3402A04871	NGS	NGS	
	872	3402A04872	NGS	NGS	
	882	3439A07882	NGS	NGS	
	883	3402A04883	NGS	NGS	
	888	3402A04888	NGS	NGS	
	269	3343A04269	NWS	NWS	(2)
	385	3503A09385	NWS	NWS	
	453	3515A10453	NWS	NWS	(A)
	057	4057	TXDOT	TXDOT	(3)
	059	4059	TXDOT	TXDOT	
	062	4062	TXDOT	TXDOT	
	063	4063	TXDOT	TXDOT	
	064	4064	TXDOT	TXDOT	
	474	3504A09474	TXDOT	TXDOT	
	487	9487	TXDOT	TXDOT	
	502	9502	TXDOT	TXDOT	
	503	9503	TXDOT	TXDOT	
	504	9504	TXDOT	TXDOT	
Trimble 4000SSi	012	3651A18012	NWS	NWS	(2)
	315	3626A16315	NWS	NWS	
	327	3627A16327	NWS	NWS	
	424	3735A20424	NWS	NWS	
	857	3610A14857	NWS	NWS	
Ashtech Z-XII3	050	05063	USCG	USCG	(4)
	066	05066	USCG	USCG	
Allen Osborne Assc. Rogue SNR 8000	338	T338	JPL	JPL	(5)

(1) National Geodetic Survey.
(2) National Weather Service.
(3) Texas Department of Transportation.
(4) U.S. Coast Guard.
(5) Jet Propulsion Laboratory.
(A) Receiver 453 is listed as SN 3515A10453 in the Site Information Log, but is listed as SN 16316 in all the headers of the RINEX observation files. The ID and serial number was left as 453 and 3515A10453 in the B-files and adjustment files.

The Trimble 4000SSE and the Trimble 4000SSI receivers measured L1 and L2 phase data in units of whole cycles. Trimble microstrip dual-frequency antenna P/N 14532-00, 22020-00, and 23903-00 were used with the Trimble receivers.

Ashtech Z-XII3 receivers measured L1 and L2 phase data in units of whole cycles. Ashtech antennae P/N 700829 (3) were used with the Ashtech receivers.

The Allen Osborne Associates ROGUE SNR 8000 receiver measured L1 and L2 phase data in units of whole cycles. A Dorne Margolin T antenna was used with the ROGUE SNR 8000 receiver.

Antenna heights were referenced to top of antenna ground plane and recorded as such on the GPS Observation logs. In the data processing, heights were referenced to the Antenna Reference Point(ARP) and antenna constant values for the ARP to L1 phase center as determined by Dr. Gerald Mader, National Geodetic Survey, Geosciences Research Division are defined in file ANT_INFO.001. This file is read by the Page4 processing software. The antenna heights (top of monument to the NGS-derived L1 phase center) are entered in the B-file.

Various lengths of RS-232 cables were used with the GPS equipment to connect the antenna to the receiver. Antennae were approximately oriented to true North.

The SECO 2.0 meter fixed height pole was used by NGS for all antenna set-ups during the project. The fixed height poles required no height measurements. The height of the fixed pole was added to the antenna constant to determine the overall height of ground plane above the station mark. The fixed height poles were plumbed over the mark by adjusting the pole until the bull’s-eye bubbles were centered. The bubbles were shaded during plumbing and for at least three minutes before checking and/or replumbing the poles. The bubble is mounted on a collar approximately four feet from the pole's base. The SECO poles can be rotated 360 degrees to determine perpendicularity and adjusted if necessary. Perpendicularity of the poles were checked at every setup.

Data were collected at 15 second epoch intervals with an elevation mask of 15 degrees.

VI. DEVIATIONS FROM PROJECT INSTRUCTIONS

There were no significant departures from standard operating procedures or from specific project instructions.

VII. DATA PROCESSING PERFORMED

A. Software Used

Trimble's datalogging program 4000 was utilized for logging and downloading Trimble data. A list of Trimble firmware versions follows:

NAV Firmware	Survey Support (Signal Software)	Downloading Software
5.70		(1)
6.11		(2)

6.12			(3)
7.09			(4)
7.12	3.04		(5)
7.26	3.07		(6)
6.12	2.12	3.11.00	(7)
7.25	3.07	3.11.00	(8)

(1) Receivers 057 and 062.
(2) Receivers 063, 064, 487, 502, 503 and 504.
(3) Receiver 474.
(4) Receiver 059.
(5) Receivers 269, 385, 453, 012, 315, 327 and 857.
(6) Receiver 424.
(7) Receiver 526 from 3/17 (Julian day 076) to 4/5 (Julian day 095).
(8) Receivers 286, 869, 871, 872, 882, 883 and 888. Receiver 526 was upgraded to this firmware on 4/6 (Julian day 096).

A list of Ashtech receiver software versions follow:

Nav	Channel	Options
1C01		(9)

(9) Receivers 050 and 066.

The Allen Osborne Assc. ROGUE SNR 8000 receiver software follows:

Version
95.03.08

The raw receiver data files from receivers 286, 526, 869, 871, 872, 882, 883 and 888 were downloaded to 3.5-inch diskettes using various computers. The data from all other receivers, all at various CORS sites, was downloaded from Scripps' FTP site and NGS's website in RINEX format.

The field office transferred the data to a Dell OptiPlex GX1 personal computer using Windows NT commands. The raw field data was placed in the DATA directory under the project ID and Julian day. NGS programs and Page4 programs were used to reformat, merge and reduce the data.

IGS precise ephemeris and broadcast orbit files were downloaded from NASA's FTP site.

Program SSE2RIN was used to reformat Trimble raw field data from a binary sequence to an ASCII sequence. The programs yielded a rough data quality check of the times of observations, number of rejections at a particular station and the number of cycle slips.

The observation data was processed using Page4 Version 9810.06.

The B-file was created using CR8BB, Version 3.21 (18JAN90).

The G-file was created using SINEX2G option in the Page4 Utilities pull-down window.

Program COMPGB was run to compare the project's B-file and G-file.

Program NEWCHKOB Version 1.4.2 was run to validate the project's B-file.

Program OBSDES Version 2.4.2 was run to compare the project's B-file and D-file.

Descriptions were digitized using DDPROC version 4.43.

Program QQRECORD was used to build the QQ records of the A-file.

The free and CORS constrained adjustments were computed using program ADJUST version 4.10.

GEOID96 was used to compute geoid heights.

Corel WordPerfect Suite 7 was used for this report and related documents.

The raw field data and processed data were transferred from hard drives to Iomega 100 zip disks using Windows NT commands.

Static processing was performed during the project.

B. Rejected Data

24 vectors were rejected from the free adjustment and the CORS constrained adjustment.

C. Office Processing

The project data was processed with the menu-driven suite of PAGE4 software. PAGE 4 is designed to run in a batch mode; once input files are created, little user interaction is normally required. The first step is to place RINEX observation files, the IGS precise ephemeris file and a broadcast orbit file in a processing subdirectory. The PAGE4 menu is then entered and the input files are created by selecting various menu items under Input Files, Station Information, and Setup Options for processing. Program default values are read from a file named DEFAULT.TXT, residing in the subdirectory containing the PAGE4 software. The user has the option to accept or modify these values while in the menu system. Once all input files are completed, the run menu can be accessed.

The seven processing steps are Merge all RINEX files (MERGEDB), Do Triple Difference Solution (TDSOLVE), Synchronize Observations (MERGEDB), Choose Baselines (STREE), Choose Reference PRNs, Fix Cycle Slips (REFPRN/EDITDB), Do the Baseline Solution (PAGE4) and Fix Integers (FIXINT/PAGE4). An eighth step in the run menu is Clean Up Output, which will delete unneeded output files that are specified by the user in the DEFAULT.TXT file. This step is executed only after the user has examined and accepted the processing solutions.

The MERGEDB execution creates a combined data base containing GPS observations from the RINEX observation files of all stations to be processed in a session. MERGEDB synchronizes the observations to common epochs using receiver and satellite clock information and reformats the pseudorange and phase observations into a standard binary format to facilitate further processing.

Program TDSOLVE computes an L3 or L1 triple difference solution and updates the Position, Offset, Meteorological data (.POM) files with improved coordinates. Once the .POM files are updated, an additional MERGEDB execution is performed.

Program STREE selects an independent baseline network by finding the “minimum spanning tree” that connects all stations. The tree is based on the length of baseline and the amount of data available. The program then modifies this tree by examining user specified items such as which stations to use as hubs, which stations are unreliable and must be connected by a spur baseline, and which baselines are to be forced to be part of the spanning tree.

After STREE is executed, program MERGEDB creates individual data bases for each baseline. Program REFPRN chooses the reference satellites to be used in the double difference processing of individual baselines. The reference satellites are selected based on the elevation angle of satellites and availability of satellites. EDITDB is an automatic data editing program. It uses the reference satellite scenarios created by program REFPRN to determine if any cycle slips exist in the data. Edit instructions to fix cycle slips or delete bad data are written to edit command (.EDT) files. Program BDATA is used to update the data bases with these edit instructions before the execution of the PAGE4 program.

Program PAGE4 first executes an ion-free (L3) double difference float solution on the combined data base. Program L3OK is run to update the coordinates in all data base header information (*HD.DAT) files with the best float-solution estimates. Program RUN_INT is then called. RUN_INT fixes integers while working on individual baselines. PAGE4 L3 solutions are run on each individual baseline and L3 ambiguities are written to the corresponding integer (.INT) files. PAGE4 wide-lane (L4) solutions are then run and the L4 ambiguities are written to the same .INT files. Program FIXINT_1 then uses the L3 and L4 ambiguities to determine the L1 and L2 ambiguities. Ambiguities meeting program criteria are then fixed. Additional PAGE4 L3 and L4 solutions are run on the individual baselines. FIXINT_1 is then executed to determine if additional integers can be fixed. The fixed integers are written to the .INT files and a final PAGE4 combined data base solution is executed. Post-fit residual plots and other output files are then examined to determine if the solution is acceptable.

Occasionally, incorrectly fixed integers were seen and an additional solution holding those integers unfixed was executed. The survey section encountered many of a total of nine hundred and forty-seven (947) baselines with what appeared to be incorrect solutions, possibly due to incorrect ambiguity fixes. There were no vectors where all fixed integers were completely unfixed.

Files BBTXRO.FRE, GTXRO.FRE (free adjustment), BBTXRO.CON and GTXRO.CON (CORS constrained adjustment) contain bluebook station observation entries and computed baselines of the B-order network. File DTXRO.HA contains the project's bluebooked station descriptions.

Programs COMPGB, OBSDES and NEWCHKOB were executed to compare the project bluebook files. Output of the program executions were directed to computer files and printed. Explanations for any file inconsistencies were appended to the printed output.

The following data peculiarities occurred:

J.D. 078

There is a 9 hour and 6 minute gap in the data from 05:41 to 14:47 UTC due to

the receiver being off at station **PALPORT**. Data for the session goes from 00:01 to 05:41 and 14:47 to 20:02 UTC. The station is a CT CORS site. The occupation of station **M 1497** was lost due to the keys to the rental car were locked in the vehicle as the operator was setting up the antenna. By the time spare keys were obtained, the session was about over.

J.D. 082

A 1 hour late start occurred at station **PATSY AZ MK**. No reason given by the operator, Eric Black. A 17 minute late start occurred at station **VINTON** as the operator had to wait for large bulls to leave the station area.

J.D. 084

A 36 minute late start occurred at station **HGCSD 73** due to the operator having difficulties finding station mark.

J.D. 085

The operator misread the work schedule resulting in a 4 minute late start at station **E 168.**

J.D. 087

Eric Black ended the session 1 hour and 30 minutes early on a 7 hour session at station **877 1510 TIDAL 46** resulting in the whole session having to be rescheduled.

J.D. 089

The first 35 minutes of data was unusable at station **HGCSD 68** due to receiver malfunction.

J.D. 091

The occupation of station **WAELDER RM 2** was lost due to operator Eric Black setting up on the wrong mark, **WAELDER**, even though the description was for the reference mark.

J.D. 092

The occupation of station **LOLITA** was missed due the mechanical failure of the government truck.

J.D. 097

Due to Daylight Savings Time, Eric Keresty started 1 hour early and collected 6 1/2 hours of data at station **REALITOS NORTH BASE RM 2**.

J.D. 100

There is a 24 minute gap from 16:40 to 17:04 UTC at station **TT37BR** due to receiver running out of memory.

J.D. 121

A 5 minute late start occurred at station **ELM**. Eric Black gave no reason.

J.D. 125

4 minute late at station **ALLISON** due to receiver malfunction.

J.D. 128

A 30 minute late start at station **ZAPATA RESET** due to the station being completely buried according to Eric Black.

J.D. 135

2 minute late start at station **ACALA** due full receiver memory.

J.D. 141

12 minute late start at station **A 1461** due to station being occupied by someone from an engineering company.

J.D. 147

14 minute late start at station **J 1487** due to the antenna cable not being completely plugged in. 45 minute late start at station **KINGSTONE RESET** due to flat tire on government truck.

J.D. 148

The data disk for station **J 1487** had a bad sector in the data file at 2 hours and 58 minutes into the data and a back-up of the data could not be found. As this station was occupied 5 other times during this project, this session at this station was dropped from the processing.

J.D. 153

9 hours and 37 minute of data was collected at station **L 550 RESET** for an unknown reason.

J.D. 154

According to Eric Keresty, strong winds during the session caused the fixed height pole to become unplumbed frequently at station **A 256**.

VIII. **STATISTICS**

A. **Stations Occupied**

1. Existing NGS Horizontal Stations 29
2. Existing NGS Vertical Stations 4
3. Existing NGS Horizontal/Vertical Stations 50

4. New GPS Stations 7
5. CORS Stations 21

TOTAL..... 111

B. **Vectors Observed**

1. Non-Trivial..... **947**
Rejected..... **24**

C. **Total Number of Sessions and Days for Project**

1. Weekend Days
March 3
April 8
May 10
June 0

TOTAL.... 21

2. Holiday
May (Memorial Day) 1

TOTAL.... 1

3. Move Days
March 1
April 1
May 0
June 0

TOTAL.... 2

4. Observing Sessions
March 12
April 21
May 20
June 3

TOTAL OBSERVING SESSIONS.... 56

5. Observing Days
March 12
April 21
May 20
June 3

TOTAL OBSERVING DAYS.... 56

TOTAL PROJECT DAYS.... 80

IX. **FIELD ACCURACY**

As per a discussion with William McLemore and Elizabeth Wade, the lack of

loops to check for loop misclosures and high number of redundant (Non-Trivial) vectors (making for a extremely high number of possible combinations of vectors to compare) led to the decision to compile the g-file position and vector files into same station positions and like vectors for a quality check of the survey data (Attachments F and G). A Free adjustment and a CORS constrained adjustment of the survey network were computed (Attachment H and J). A separate report titled "MEMORANDUM FOR THE RECORD" (Attachment K) describes processing activities and results.

X. RECOMMENDATIONS AND COMMENTS

The project instructions for future projects and some of the checking programs should be upgraded to reflect the modernization of the data processing.

XI. ATTACHMENTS

A. Project Instructions
B. Project Sketch
C. Station Listing/Fixed Control Data
D. Observation Schedules
E. Navstar User's Bulletins
F. Redundant Vector from Vector G-file
G. Station Positions from Position G-file
H. Free Adjustment
I. CORS Constrained Adjustment
J. Comparison to Published Positions and Elevations
K. Processing Report
L. Correspondence
M. Bluebook File Comparison Output
N. Photographs
O. Length Relative Accuracies (Free)
P. Length Relative Accuracies (CORS Constrained)
Q. Distribution of Ellipsoid Height Accuracies
R. Obstruction Diagrams
S. Failure Reports
T. Occupation Log
U. Adjacent Ties

Prepared By,

Gary A. Means
Surveying Technician
NGS Survey Section B

Reviewed, Submitted,

Clifton S. Middleton
Project Director
NGS Survey Section B

April 2, 1999

MEMORANDUM FOR THE RECORD

FROM: Gary A. Means, Computer
Survey Section B

SUBJECT: Texas FBN, 1998

The GPS project, Texas FBN, 1998 (GPS-1267, processing id: txro038d.605) was observed by the National Geodetic Survey Section B (Project Director Clifton S. Middleton) from March 13, 1998 through June 3, 1998. The project employed twenty-one (21) Trimble 4000SSE receivers, five (5) Trimble 4000SSI receivers, two (2) Ashtech Z-XII3 receivers, and one (1) Allen Osborne Turbo Rogue receiver.

The objectives of the survey:

1) To support the National Geodetic Survey (NGS) Strategic Plan by observing stations of the Federal Base Network (FBN) to complete the ellipsoidal and orthometric height components of the FBN. The project is to also support software tests that will determine if FBN surveys can be computed along with standard CORS processing. Seven tide sites along the Gulf of Mexico, six stations in the Harris-Galveston Coastal Subsidence District (HGCSD), and four other HGCSD stations from a previous project were included in the project.

2) To meet America's accelerating positioning and navigation needs by enhancing the existing coordinate reference system to provide the accessibility and high accuracy required for use by GPS. The digital revolution in mapping, charting, and surveying requires a National Spatial Reference System (NSRS) consisting of, among other components, a network of monumented points having four-dimensional positions. The FBN fulfills the requirements for this component and NGS is charged with the Federal responsibility for establishment, observation, monitoring, and maintenance of the FBN.

3) The NSRS provides the common geographic framework for America's spatial data infrastructure. In this capacity, the NSRS serves as the basis for mapping, charting, navigation, boundary determination, property delineation, infrastructure development, resource evaluation surveys, and scientific applications, including crustal motion monitoring, modeling of flooding, storm surge, pollution trajectories, and agriculture runoff. A modernized, accurate, consistent, and reliable NSRS is of enormous benefit to state, county, tribal, local, and federal authorities, as well as the private sector.

4) To provide survey ties to the seven tide sites to give GPS-derived ellipsoid heights, accurate to 3 cm, on tide water-level marks along the coast.

5) To provide survey ties to the six additional and four re-observed HGCSD stations to give GPS-derived ellipsoid heights, accurate to 3 cm, and a tie between the local network and the national FBN network. It is to also provide a check to determine if the ellipsoid heights can be repeated to within 3 cm in the HGCSD area.

Gary A. Means of Survey Section B, performed all final processing utilizing the menu-driven suite of PAGE4 processing package version 9810.06 software. The selected observation interval for processing this project was 30 seconds. A minimum angle of 15E above the horizon was selected as the cutoff for all carrier phase observables in the data reductions. Precise ephemerides determined by the International GPS Service for Geodynamics (IGS), referenced to the ITRF96, Epoch 1997.0 coordinate system, were used in all data reductions. After all cycle slips in frequencies L1 and L2 were removed from the data, final solutions were obtained using the L3 option (ionosphere-free linear combination of frequencies L1 and L2). After all cycle slips in frequencies L1 and L2 were removed from the data, final solutions were obtained using the L3 option (ionosphere-free linear combination of frequencies L1 and L2).

PAGE4 Processing

A-order stations connected during the survey include A 1236, ACALA, ALLAMORE, AUSTIN, EL PASO, H 506, M 1396, P 1391, QUEBEC RESET, R 1446, REDFIELD 2, WILKENS W BASE RESET, Y 1482, and Z 1063. Continuously Operating Reference Stations (CORS) connected during the survey include ARANSAS PASS 3 CORS ARP, GALVESTON 1 CORS ARP, JAYTON CORS ARP, MCDONALD CORS MONUMENT, PALESTINE CORS ARP, DEQUEEN 1 CORS ARP, WINNFIELD CORS ARP, TUCUMCARI CORS ARP, WHITE SANDS CORS ARP PURCELL CORS ARP, VICI CORS ARP. Texas Department of Transportation CORS connected during the survey include AMARILLO RRP CORS ARP, SAN ANTONIO RRP CORS ARP, ARLINGTON RRP CORS ARP, AUSTIN RRP CORS ARP, BEAUMONT RRP CORS ARP, CORPUS CHRISTI RRP CORS ARP, HOUSTON RRP CORS ARP, LUBBOCK RRP CORS ARP, ODESSA RRP CORS ARP, and EL PASO RRP CORS ARP. The final reductions consist of a total of 111 stations; 29 existing horizontal stations, 4 existing vertical stations, 50 existing horizontal/vertical stations, 7 new GPS station, 11 CORS stations, and 10 TXDOT CORS stations.

The number of receivers used per observing session were thirteen receivers (one session), fourteen receivers (one session), fifteen receivers (five sessions), sixteen receivers (three sessions), seventeen receivers (nine sessions), eighteen receivers (fourteen sessions), nineteen receivers (twelve sessions), and twenty receivers (eleven sessions). A total of fifty-six processing sessions were computed with a resultant yield of 947 vectors, of which 24 were reject. This resulted in 923 high precision vectors.

Ambiguity biases were fixed whenever possible. All integers were fixed for 143 vectors (15.10%), 804 vectors (84.90%) were partially fixed, and no vectors (0.00%) were float solutions.

The data collected during a single observing session were computed in single, double or triple processing sessions depending on length of baselines and project instructions. All observations were made within the year of 1998. The stations were separated into two different groups on the dates of March 17, 18, 19, 26, 28, 30, and 31 (Julian days 76, 77, 78, 85, 87, 89 and 90), and February 1, 10, 13, 14, 15, 16, and 21 (Julian days 91, 100, 103, 104,

105, 106, and 111) because some baselines were short enough to require L1 fixed solutions. The stations were separated into three different groups on February 20 (Julian day 111) because of the lengths of baselines. All other observations were processed as one session.

The consistency comparison of the G-file and B-file was performed using program COMPGB with program output directed to file COMPGB.OUT. A hard copy of the output is printed and explanation of inconsistencies are appended to the project report in Attachment M.

Final Results

A minimally constrained least squares adjustment using program ADJUST (version 4.10) was performed with station MCDONALD CORS MONUMENT held fixed to NAD83 coordinates with relative length accuracies computed. The adjustment "a posteriori" standard deviation of unit weight was 8.90 and the variance of unit weight was 79.17. The computed root-mean-square of the residuals in this adjustment were 0.3 cm in latitude, 0.5 cm in longitude, and 0.8 cm in geodetic (ellipsoidal) height. The computed mean absolute residuals were 0.2 cm in latitude, 0.3 cm in longitude, and 0.6 cm in height.

As per a conversation with Elizabeth Wade and William McLemore, it was decided not to check the precision of all independently observed repeated baselines due to the extremely high number of repeated vectors and the incredible number of possible combinations. It was decided that compiling the position and vector files created by synex2g into files and print-outs (see attachments F and G) that could be checked for repeatability.

A least squares adjustment constraining the CORS stations ARANSAS PASS 3 CORS ARP, GALVESTON 1 CORS ARP, JAYTON CORS ARP, MCDONALD CORS MONUMENT, PALESTINE CORS ARP, DEQUEEN 1 CORS ARP, WINNFIELD CORS ARP, TUCUMCARI CORS ARP, WHITE SANDS CORS ARP, PURCELL CORS ARP, and VICI CORS ARP held fixed to NAD83 coordinates was performed with relative length accuracies computed. The adjustment “a posteriori” standard deviation of unit weight was 11.02 and the variance of unit weight was 121.42. The computed root-mean-square of the residuals in this adjustment were 0.3 cm in latitude, 0.5 cm in latitude, and 1.1 cm in geodetic height. The computed mean absolute residuals were 0.2 cm in latitude, 0.3 cm in longitude, and 0.8 cm in height.

Program DIFLATLN was used to compute inverses between the free adjustment positions and NGS data base positions and between the CORS constrained adjustment and NGS data base positions (see attachment J). There were five stations that had horizontal shifts greater than 0.04 meters. These were:

NAME	ORDER	FREE ADJ SHIFT	CORS CONSTRAINED SHIFT
ACALA	HA	0.046 M	0.047 M
G 1432	HB	0.046 M	0.046 M
LINN	HB	0.063 M	0.060 M
R 1446	HA	0.041 M	0.040 M
VINTON	HB	0.045 M	0.045 M